Rotzell (W. E.)

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USE AND DISUSE.

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It is a generally recognized fact that the increased use of any structure or organ in the animal anatomy, within certain limits, results in the enlargement of that part, and disuse of an organ or structure usually results in its atrophy or degeneration.

The development of an organ through use may be readily illustrated: thus, when a young person actively engaged loses a limb, the remaining limb, being more used than formerly, will rapidly increase in strength.

A case of this character is recorded by J. Bland Sutton (*Evolution and Disease*). The subject was a woman, fifty years of age, who had her great toe amputated, including the metatarsal bone. Six months after she had regained the use of the foot, the second toe had greatly enlarged and stood out from its fellows in such a way as to resemble in size and general appearance the lost toe. When the case was exhibited before the class the enlarged second toe, possessing such a strong resemblance to, was mistaken for the hallux.

This illustration is of significance and importance, the very rapid development of the toe being the result of the large amount of use which it serves in those members of the mammalia which maintain an erect or semi-erect position. These same facts apply equally well to the thumb, which is proportionally so much stronger than the other digits.

The gradual enlargement of a digit and its transmission to succeeding generations through heredity are well illustrated in the ancestry of our modern horse. The horse, as we all know, walks upon its hoof; this hoof is a modification of the nail and serves as the end covering of the single digit which

the horse possesses. On each side of this functional digit is found two bones known as splint bones; these at one period in the life history of the horse were well developed into functional toes, but as they were of little or no use to the animal, they have through disuse almost disappeared and now are merely vestigial structures.

Relative to this subject Prof. E. D. Cope (*Origin of the Fittest*) says: "The reduction in the number of toes is supposed to be due to the elongation of those which slightly exceed the others in length, in consequence of the greater number of strains and impacts received by them in rapid progression, and the complementary loss of material available for the growth of the smaller ones. This is rendered probable by the fact that the types with reduced digits are dwellers on dry land, and those that have more numerous digits are inhabitants of swamps and mud. . . . . The mechanical effect of walking in the mud is to spread the toes equally in opposite sides of the middle line, as in the cloven-footed types. In progression on hard ground the longest toe (the third) will receive the greatest amount of shock from contact with the earth. There is even reason to believe that shocks, if not excessive, encourage growth in the direction of the force applied. This is strongly suggested by the relations between the length of the legs and the rate of speed of animals, and the lengths of the teeth and their long-continued use."

Many interesting illustrations of enlargement from use can be cited in the muscular system and in the paired organs. Thus frequently after the removal of a testicle, its fellow greatly enlarges, and compensates to a certain extent for the lost one. Similar enlargement occurs after the removal of a kidney.

A structure about which much has been written and said, and which is probably the result of disuse, is the vermiform appendix, which is doubtless the remains of the much elongated cæcum which is found in the majority of the herbivorus mammals. In man and the four anthropomorphous apes, the lower end of the cæcum has attached to it the vermiform appendix, which varies in length from about two to eight inches; this appendix is also found in the wombat, a marsupial mammal, which has many characteristics of the rodents.

In the orang the appendix is longer than in man, and in the

human fœtus it is proportionally more developed than in the adult. Occasionally the appendix is absent.

A very interesting paper on this subject was recently published by Dr. Edward Cranch, of Erie, Pa., in which he endeavors to demonstrate that the appendix is not a useless organ, but that its function is to secrete mucus for the lubrication of the large intestine. Of course all mucous membranes secrete more or less mucus, but the quantity secreted by the appendix would certainly be inadequate to be of any special service in the human economy, when we consider the variability in the size of the appendix, and its occasional absence, besides, after the removal of the appendix the individual realizes no inconvenience from the loss. In the paper referred to the mucus secreted by the appendix is given the same status as the saliva, gastric juice, pancreatic juice, etc.; certainly none of these secretions could be discontinued, as can the mucous secretion of the appendix, without causing deleterious results upon the system.

The teeth of modern civilized man show to a certain extent the result of disuse. This is owing to the manner in which our food is prepared, the thoroughness of mastication which is practiced by savage races not being necessary for civilized man. This theory is confirmed by the fact that the third molars, or wisdom teeth, are with each succeeding generation becoming more and more rudimentary. These teeth are now usually the last to make their appearance in the jaw and the first to disappear; they are smaller and more variable than the other molars, and have only two separate fangs. In the older remains of man they have three separate fangs, as they still have in the Melanian races.

In the organs of special sense the results of use and disuse are easily recognized. Thus, for example, when hearing is lost in early life in one ear the power of hearing becomes very acute in the remaining ear. In blind persons the sense of hearing is usually very acute, it compensating to a certain extent for the loss of sight.

Exceptionally fine development of the special senses is frequently met with in certain occupations, as the acute hearing of the musician, the sight and touch of the artist, engraver, etc.

The result of use is well expressed in the old adage of "Practice makes perfect;" this could be improved upon I think by inserting *within certain limits*, because excessive use of a part, in some cases at least, results in the extermination of other characteristics. Examples of modification caused by use and disuse can be found throughout the whole of the animal world, and these factors, I think, can be considered as the most important of the causes of morphological variation.

Among both wild and domesticated animals illustrations can be cited in abundance. The wings of the birds of oceanic islands have diminished in size, owing to disuse, as likewise have the eyes of many cave animals. In some birds the wings have so degenerated that they are of small value as organs of flight, as, for example, the wings of the ostrich, the Great Auk, now extinct, and some domesticated birds. Among the birds of prey, the flesh-eating birds, the muscular walls of the gizzard are comparatively thin, while among those birds which subsist upon grain the walls of the gizzard are quite thick.

The direct cause of enlarged parts through use is irritation and additional blood supply, which constitutes increased nutrition. This increased nutrition is caused by such stimuli as irritants, certain conditions of the nervous system and environment.

The scales of serpents, the feathers of birds, the quills of porcupines, and bristles of hogs are like hair, epidermis, and horn, all modifications of the epithelium, and are the result probably of different internal and external conditions to which the animal has been subjected. These modifications are usually transmitted to succeeding generations.

Development through use also furnishes an explanation of the power of scent in many animals, the sight of the birds of prey, and the cunning of foxes and wolves.

Disuse, on the other hand, usually follows defective nutrition, the *causa causarum* of which is probably environment. Thus in the case of the teeth of civilized man the environment has been such that it is not necessary for us to use our teeth at present to such an extent as man formerly did, and consequently they have degenerated, and as continued degeneration can, and does, result in extinction, Prof. Haeckel and others have ventured to prophesy that unless the teeth, and some of

the other structures possessed by man, are used more than they are at the present time, that ultimately they will totally disappear.

It seems to me that these facts are of the greatest importance not only to the biologist, but also to the practical physician. I think there is too much of a tendency among physicians to correct physical variations, without taking into consideration the laws of heredity. When cases are thus treated, while, of course, in the majority of instances they are benefited, nevertheless the possibilities of hereditary transmission of these abnormalities to succeeding generations is increased, and thus does not tend to the improvement of the race. Thus in cases where the various supports, as the truss, for example, are used, and also in using lenses for the correction of errors of sight, when relief only is obtained and not cure. The result is that the race must ultimately suffer in consequence.

According to the methods of nature each useful organ or structure will ultimately perfect itself, *i.e.*, will adapt itself to its environment. By the mechanical methods now in vogue, perfection will never be obtained. It is easy to recognize that our methods of treatment are not ideal, but to suggest the remedy is practically impossible. All that can be said is that we should see that every patient, including every organ and characteristic of that patient, is adapted, as nearly as possible, to the environment in which he is placed. This can be secured, theoretically, by adapting the subject to its environment, or by modifying the environment to the needs of the subject, or by changing both subject and environment, making each as perfectly adapted to the other as possible.